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Life events and haemodynamic reactions to acute mental stress in the middle-aged and elderly

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Running Head: Life Events and Stress Reactivity

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Abstract

Recent versions of the reactivity hypothesis, which consider it to be the product of stress exposure and exaggerated haemodynamic reactions to stress that confers cardiovascular disease risk, assume that reactivity is independent of the experience of stressful life events. This assumption was tested in two substantial cohorts, one middle-aged and one elderly. Participants had to indicate from a list of major stressful life events up to six they had experienced in the previous two years. They were also asked to rate how disruptive and stressful they were, at the time of occurrence and now. Blood pressure and pulse rate were measured at rest and in response to acute mental stress. Those who rated the events as highly disruptive at the time of exposure and currently exhibited blunted systolic blood pressure reactions to acute stress. The present results suggest that acute stress reactivity may not be independent of stressful life events experience.

Descriptors: Acute stress, Blood pressure, Life events, Reactivity

Life events and haemodynamic reactions to acute mental stress in middle-aged and elderly men and women.

Exaggerated haemodynamic reactions to acute mental stress have been implicated in the development and expression of cardiovascular disease (Jennings, Berg, Hutcheson, Obrist, Porges, et al., 1981; Lovallo & Gerin, 2003; Manuck, 1994; Schwartz, Gerin, Davidson, Pickering, Brosschot, et al., 2003; Treiber, Kamarck, Schneiderman, Sheffield, Kapuku, et al., 2003). However, most prospective studies to date have tested what might be referred to as a main effects model (Carroll, Smith, Shipley, Steptoe, Brunner, et al., 2001), i.e. that high reactivity *per se* is pathogenic. Collectively, such studies indicate that high magnitude haemodynamic reactions to stress confer a modest but reasonably consistent risk for developing high blood pressure (Carroll, Ring, Hunt, Ford, & Macintyre, 2003; Carroll, Smith, Sheffield, Shipley, & Marmot, 1995; Carroll, et al., 2001; Everson, Kaplan, Goldberg, & Salonen, 1996; Markovitz, Raczynski, Wallace, Chettur, & Chesney, 1998; Matthews, Woodall, & Allen, 1993; Treiber, Turner, Davis, & Strong, 1997), thickening of the carotid intima wall (Lynch, Everson, Kaplan, Salonen, & Salonen, 1998), and increasing left ventricular mass (Allen, Matthews, & Sherman, 1997). However, it has been argued that such main effects models are likely to underestimate the role of stress in cardiovascular disease and that it is important to take into account variations in the frequency and/or potency of stress exposures in addition to variations in the haemodynamic perturbations contingent on a particular stress exposure (Carroll & Sheffield, 1998; Lynch, et al., 1998). The simple assumption here is that it is the product of exposure history and reactivity that confers risk. Although such a proposition seems reasonable, it does presume that reactivity levels are independent of individuals' histories of exposure to stressful life events.

It has been hypothesised, however, that high levels of background stress may be sensitising, serving to increase haemodynamic reactions to acute stress (Roy, Steptoe, & Kirschbaum, 1998). If this were the case, it is possible that variations in stress exposure have already, to an extent, been accounted for in individual differences in acute reactivity. There is some evidence in support of the sensitisation hypothesis. For example, the frequency of chronic stress exposures, lasting nine months or more, but not more episodic stress exposures, was found to be positively associated with blood pressure and heart rate reactions to a mental arithmetic stress task (Lepore, Miles, & Levy, 1997). Children and adolescents with high levels of ongoing background stress showed larger increases in diastolic blood pressure and

total peripheral resistance to a battery of stress tasks (reaction time, forehead cold stress, mirror tracing, and a social competence interview) than those with little background stress (Matthews, Gump, Block, & Allen, 1997). It has also been reported that a high frequency of life events sensitises haemodynamic stress reactions to a mental arithmetic task in young male fire-fighters; however, this effect only emerged for individuals with large support networks (Roy, et al., 1998).

By contrast, a larger number of studies examining the effects of differences in exposure to life events on acute stress reactivity have found a negative relationship, i.e. that high life events exposure is associated with blunting of haemodynamic reactivity. If the stressful experiences serve to blunt reactivity, then a simple multiplicative, stress exposure history × reactivity, model would again be problematic. In an early study, high scores on a life events inventory were associated with reduced diastolic blood pressure reactions to a mental arithmetic stress task in students, but only for participants with a positive family history of hypertension (Jorgensen & Houston, 1989). Two studies of adolescents have also found associations that similarly suggest that high life events exposure blunts haemodynamic reactions to acute laboratory stress. Life event scores were inversely related to heart rate and blood pressure reactions to mental arithmetic, a video game, and the cold pressor test (Boyce & Chesterman, 1990), and to a car-driving simulation task (Musante, Treiber, Kapuku, Moore, Davis, et al., 2000). In a study of young to middle-aged men and women, those with higher scores on a composite measure of chronic stress displayed lower systolic blood pressure reactions to mental arithmetic and public speaking tasks (Matthews, Gump, & Owens, 2001). In another recent large scale study of young adults, systolic blood pressure and pulse rate reactions to an acute mental arithmetic stress were negatively associated with the total number of life events and the number of personal life events experienced in the previous 12 months, whereas diastolic blood pressure reactivity was negatively associated with the number of work, education, and money related events (Phillips, Carroll, Ring, Sweeting, & West, in submission).

There are also a number of studies that have found no relationship between chronic stress and acute haemodynamic reactivity. For example, young to middle-aged participants high and low in recent life events did not differ in haemodynamic reactions to stressful film presentations (Vingerhoets, Ratliff-Crain, Jabaaij, Menges, & Baum, 1996), or a stressful teaching exercise (Benschop, Brosschot, Godaert, de Smet, Geenen, et al., 1994). Further, in

a study of undergraduates, there was no association between life events stress and cardiovascular reactivity to a brief intelligence test challenge (Pardine & Napoli, 1983). Clearly, as yet, there is no unanimity as to whether stressful life events exposure is associated with increased or decreased haemodynamic reactions to acute laboratory stress. It is also difficult at this stage to easily attribute variations in results to factors such as the age and sex of participants, or the acute laboratory stress tasks employed. Only further research will bring the necessary resolution. One difficulty is that, with the exception of three sizable population studies, in youths (Matthews, et al., 1997; Musante, et al., 2000) or in young adults (Phillips, et al., in submission), most of the previous studies have tested modestly sized samples. It is possible that larger adult sample sizes are required to clarify the precise nature of the relationship between chronic stress and acute stress reactivity. Another issue is that studies have included fairly minor, and sometimes positive, events in their assessment (Boyce & Chesterman, 1990; Jorgensen & Houston, 1989; Matthews, et al., 1997; Matthews, et al., 2001; Musante, et al., 2000; Pardine & Napoli, 1983; Phillips, et al., in submission; Pike, Smith, Hauger, Nicassio, Patterson, et al., 1997). In addition, previous studies have largely focussed on younger populations. Given that there are age-related variations in cardiovascular reactions to stress (Carroll, Harrison, Johnston, Ford, Hunt, et al., 2000), and an increased likelihood of exposure to severe life events with age, it is important to examine the association between major negative life events and cardiovascular reactivity to acute stress in a large population of middle-aged and older adults.

The present study, therefore, examined the relationship between the experience of major negative life events and acute cardiovascular reactions to mental stress in large cohorts of middle-aged and elderly men and women. On the basis of the prevailing impression from previous research, it is hypothesised that individuals experiencing events that have substantial psychological impact will be characterised by blunted rather than enhanced haemodynamic reactivity to acute mental stress. In addition, the size and disposition of these cohorts provide an opportunity for examining the effects of age, sex and occupational status on any such associations.

Method

Participants

Data are derived from the middle and eldest of the three age cohorts of the West of Scotland Twenty-07 Study; the individuals were all from the Glasgow area and have been followed up at regular intervals since the baseline survey in 1987 (Ford, Ecob, Hunt, Macintyre, & West, 1994). Members of the middle cohort were all around 44 years old and members of the older cohort were all around 63 years old at the third follow-up when data on life events and cardiovascular reactivity were collected. These data were available for 608 participants, 371 from the middle cohort and 237 from the older cohort. The mean age of the middle cohort was 44.1 (SD = 0.88) years and the mean body mass index was 26.2 (SD = 4.33) kg/m^2; the analogous statistics for the older cohort were 63.1 (SD = 0.65) years and 26.4 (SD = 4.61) kg/m^2. Overall, there were 269 (46%) men and 316 (54%) women, and 254 (43%) of the participants came from manual and 331 (57%) from non-manual occupational households. The sex division was virtually identical for the two cohorts: 170 (46%) men and 201 (54%) women for the middle cohort and 107 (45%) men and 130 (55%) women for the older cohort. There was, however, a tendency for the middle cohort to contain proportionally more individuals from non-manual occupational households, $\chi^2(1) = 3.52$, $p = .07$; in the middle cohort, 159 (43%) came from manual and 212 (57%) from non-manual occupational households, whereas for the elder cohort the figures were 120 (51%) and 117 (49%).

Apparatus and procedure

A full description of the testing procedure is available elsewhere (Carroll, et al., 2003). Testing sessions were conducted by trained nurses in a quiet room in the participants' homes. Demographic information was obtained by interview. Household socioeconomic position was classified as manual and non-manual from the occupational status of the head of household, using the Registrar General's (General, 1980) classification system of occupations. Head of household was either the participant or his/her partner, depending on which of the two held or had held the highest status occupation. Height and weight were measured and body mass index computed.

Major life events over the past two years and their initial and current impact were assessed by presenting participants with eight cards each of which listed a number of major life events in one particular domain. The domains were as follows: health (e.g. serious illness diagnosed), marriage (e.g. living apart or divorce), relationships (e.g. serious disagreement within family), deaths (e.g. spouse died), work (e.g. unemployment), housing (e.g. problem with landlord), finance (e.g. problems paying bills), and general (e.g. burglary or theft)[1].

Participants were asked to indicate up to six events which had happened either to them or to someone they cared about. The present analyses focussed on those events that had happened directly to the participant. Following identification of the events, participants were asked to specify, for each event, how much the event disrupted or changed their life and how stressful it was at the time of occurrence, as well as how disruptive and stressful it was now. All of these responses were scored on a 5-point scale, where 1 = a very great deal and 5 = not at all; for the analyses, the values were reversed so that the greater the impact the higher the score. Concern lay with the average impact per life event and the following key variables were derived: the average ratings per event of disruptiveness and stressfulness at the time of occurrence and extent to which, on average, these events remained disruptive and stressful now. In addition, participants were asked for each event to indicate how serious the event was on a 10-point scale, where 1 = 'something really small and unimportant' and 10 = 'the worst thing that could happen to you'. The present assessment method is based on the well-established Life Events and Difficulties Schedule (Brown & Harris, 1989) and includes the same domains of personal experience. It is common in life events inventories to provide some measure of impact as well as simply considering the number of events experienced. For example, a well-used inventory (Holmes & Rahe, 1967) measures both the frequency of events, and attaches weightings of how much adjustment would be necessary for each event, as does the more recently developed life events scale for students (Linden, 1984). What is relatively novel about the present method is that it does not provide pre-determined weightings but allows participants to make these judgments for themselves.

The stress task was the paced auditory serial addition test, which has been shown in numerous studies to reliably perturb the cardiovascular system (Phillips, et al., in submission; Ring, Burns, & Carroll, 2002; Ring, Carroll, Willemsen, Cooke, Ferraro, et al., 1999; Ring, Carroll, Willemson, Cooke, Ferraro, et al., 1999; Winzer, Ring, Carroll, Willemsen, Drayson, et al., 1999). Participants were presented with a series of single digit numbers by audiotape and requested to add sequential number pairs while retaining the second of the pair in memory for addition to the next number presented, and so on throughout the series. Answers were given orally and, if participants faltered, they were instructed to recommence with the next number pair. The number of correct answers was recorded as a measure of performance. The first sequence of 30 numbers was presented at a rate of one every four seconds, and the second sequence of 30 at one every two seconds. The whole task took three minutes, two minutes for the slower sequence and one minute for the faster sequence.

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate were determined by an Omron (model 705CP) semi-automatic sphygmomanometer. The Omron 705CP is a semi-automatic blood pressure measuring device recommended by the European Society of Hypertension (O'Brien, Waeber, Parati, Staessen, & Myers, 2001). Following questionnaire completion (approximately an hour), there was then a formal 5-minute period of relaxed sitting, at the end of which a resting baseline reading of SBP, DBP, and pulse rate was taken. Task instructions were then given and the participant allowed a brief practice to ensure that they understood task requirements. Two further SBP, DBP, and pulse rate readings were taken during the task, the first initiated 20 seconds into the task (during the first slower sequence of numbers), and the second initiated 110 seconds later (at the same point within the first of the fast sequence). For all readings, the nurses ensured that the participant's elbow and forearm rested comfortably on a table at heart level. The two task readings were averaged and the resting baseline value subsequently subtracted from the resultant average task value to yield reactivity measures for SBP, DBP and pulse rate for each participant.

Data analyses

ANOVA was used to test for differences between cohorts, manual versus non-manual groups, and men and women. Repeated measures (baseline, task) MANOVA was used to establish that the increases in SBP, DBP, and pulse rate to the stress task were statistically significant; the between group variable was the participant cohort. Throughout, eta-squared (η^2) is reported as a measure of effect size. With regard to life events, we opted to perform separate analysis for the number of life events and their average impact, since event number and average impact contained largely unique information. The correlations between the four average impact scores and the number of life events ranged from .07 to .09. In contrast, the values generated by summing the number of events weighted for their impact, a more conventional measure of stress load, was almost perfectly correlated with the number of events *per se*. Coefficients ranged from .87 to .97, i.e. these weighted sums provided no additional information to that afforded by the simple number of events. Correlational analyses were undertaken to determine the association between the measures of life events exposure and cardiovascular reactivity, where reactivity was computed as the difference between the task and baseline values for each variable. Where statistically significant bivariate associations emerged, analysis proceeded using hierarchical linear regression, in which at step 1, various possible confounders (i.e., body mass index, performance score on

the task, cohort, occupational status, and sex) were entered. In each of the models, the life events measure was entered at step 2. Moderation analyses were then undertaken, again using hierarchical regression, to test whether associations between life events and reactivity were moderated by cohort, occupational status, and sex. As recommended to avoid multicolinearity (Aiken & West, 1991; West, Aiken, & Krull, 1996), the independent and potential moderator variables were mean centred and their products derived to test for interaction effects. The potential confounders were entered at step 1, with the exception of cohort in the models testing cohort as a main effect, occupational status in the models testing occupational status as a main effect, and sex in the models testing sex as a main effect. The main effects were entered at step 2, and the interaction at step 3. Interaction effects were then plotted using values corresponding to one SD above and below the mean of the predictor variable.

Results

Life events

The mean number of major negative life events happening to the participants over the last two years was 1.86 (SD = 1.14). Although few events were experienced, they were clearly regarded as serious; the average seriousness score was 6.52 (SD = 2.17) on a scale of 1-10. With regard to the average impact, the mean disruption scores at the time of the event and now were 3.34 (SD = 1.21) and 2.24 (SD = 1.22) respectively, and the mean stressfulness scores then and now were 3.83 (SD = 1.02) and 2.27 (SD = 1.13); these values arise from ratings on a 1-5 scale. The associations between the different measures of life events impact are presented in Table 1. As would be expected, the different measures of impact were correlated. The middle cohort identified more life events than the older cohort, $F(1,606) = 9.11$, $p = .003$, $\eta^2 = .015$. However, the older cohort regarded the events that happened to them as being more serious, $F(1,606) = 9.09$, $p = .003$, $\eta^2 = .015$. There were no significant cohort differences in how disruptive or stressful, on average, the events were, either at the time they occurred or now. Manual and non-manual occupational household groups did not differ in terms of the number of events experienced, their average seriousness, nor in their average contemporary and present impact. Although there was no sex difference in the number of events reported, women regarded the events experienced as, on average, more serious, $F(1,606) = 10.22$, $p = .001$, $\eta^2 = .017$. They also regarded them as more disruptive at the time, $F(1,606) = 5.51$, $p = .02$, $\eta^2 = .009$. Similarly, women also reported that the

events experienced were, on average, more stressful at the time, F (1,606) = 22.78, $p < .001$, $\eta^2 = .036$, and now, F (1,606) = 11.66, $p = .001$, $\eta^2 = .019$. The summary life events data for the two age cohort, sexes and occupational groups are presented in Table 2.

[Insert Table 1 and 2 about here]

Haemodynamic reactivity

The mental stress task successfully perturbed cardiovascular activity; SBP, F (1, 606) = 585.80, p <.001, $\eta^2 = .492$, DBP, F (1, 606) = 422.73, p <.001, $\eta^2 = .411$, and pulse rate, F (1, 606) = 335.08, p <.001, $\eta^2 = .356$, all increased substantially. The summary data are presented in Table 3. In addition, although SBP, F (1, 606) = 102.22, p <.001, $\eta^2 = .144$ and DBP, F (1, 606) = 4.44, p =.007, $\eta^2 = .007$, were higher overall in the eldest cohort, the non-significant interaction effects indicated that the cohorts did not differ in terms of the magnitude of their blood pressure reactions to the mental stress task. Pulse rate did not vary significantly between cohorts. There was, however, a significant interaction effect, F (1, 606) = 7.99, p <.001, $\eta^2 = .013$; the middle cohort exhibited larger pulse rate reactions than the eldest cohort to the mental stress task.

[Insert Table 3 about here]

Association between life events impact and haemodynamic reactivity

For the sample as a whole, neither the number of negative life events nor their average estimated seriousness correlated significantly with the magnitude of haemodynamic reactions to acute mental stress. However, analyses revealed negative associations between the average impact of events in terms of their perceived disruptiveness and stressfulness and cardiovascular reactivity: the greater the average perceived impact, the smaller the cardiovascular reactions to mental stress. These associations are summarised in Table 4. As can be seen, they are only statistically significant for SBP reactivity, and the relationships are more evident for current rather than original impact.

[Insert Table 4 about here]

The outcome of hierarchical regressions, with SBP reactivity as the dependent variable and in which cohort, sex, body mass index, occupational status, and performance on the

mental stress task were entered at step 1 and the life events variables individually at step 2, are presented in Table 5. Only the models in which life events were significantly associated with reactivity are presented. SBP reactivity was predicted by the average score for disruption at the time of the event and the average score for disruption now; such that the greater the disruption, the lower the SBP reaction to the stress task. In these hierarchical regressions, adjusting for the other potential confounding variables, sex, body mass index, and performance score were significantly associated with SBP reactivity at step 1 and remained so at step 2. As can be seen from Table 5, at step 1, being female, having a higher body mass index, and a lower performance score, were associated with blunted SBP reactivity to acute stress. These analyses were also repeated with baseline SBP added to the other variables entered at step 1. Although there was a highly significant negative relationship between baseline SBP and SBP reactivity, B = -0.17, 95%CI = -0.22 to -0.12, β = –0.30, t = 6.80, p <.001, the associations between life events disruptiveness then, B = -0.97, 95%CI = -1.73 to -0.21, β = –0.10, t = 2.52, p = .02, and now, B = -1.17, 95%CI = -1.91 to -0.40, β = –0.12, t = 3.08, p = .002, and SBP reactivity withstood adjustment for baseline SBP.

[Insert Table 5 about here]

Moderation Analyses

The outcomes of correlational analyses applied to the life events impact variables and SBP reactivity separately for the two age cohorts, the two sexes, and the two household occupational groups are summarised in Table 6. The negative associations between current impact and reactivity tended to be more compelling for the older cohort and for women. For manual and non-manual occupational groups, the pattern of correlations was similar, with one exception; for those from manual occupational households there was a positive association between the number of events reported and SBP reactivity. Formal moderation analysis was undertaken to determine whether the associations between life events and SBP reactivity were moderated by sex (0 = men, 1 = women), occupational status (0 = non-manual, 1 = manual), cohort (0 = 43 years, 1 = 63 years). There was no evidence of moderation by sex or cohort, nor did the associations between the average disruptiveness and SBP reactivity appear to be moderated by occupational status, as indicated by significant interaction effects. However, a significant occupational status × life events interaction effect emerged for the number of life events experienced. More frequent life events exposure was associated with a pronounced blunting of SBP reactivity for people from non-manual occupational households, whereas

greater overall life events exposure appeared to sensitise reactivity for individuals from manual occupational households, B = 2.17, 95%CI = 0.50 to 3.84, t = 2.55, p = .01. This effect is displayed in Figure 1. Subsequent analyses revealed that the individual slopes for non-manual, B = –0.92, 95%CI = –2.02 to 0.17, t = 1.66, *p* = .10, and manual participants, B = 1.24, 95%CI = –0.03 to 2.51, t = 1.92, *p* = .06, did not differ significantly from zero, although in both cases, the slopes approached statistical significance.

[Insert Table 6 and Figure 1 about here]

Discussion

The present study revealed, in a substantial adult population, a negative relationship between the impact of stressful life events, particularly their disruptiveness, and haemodynamic reactivity to acute stress. This result is seemingly in line with the findings of the majority of previous studies showing that higher life event scores are associated with blunted haemodynamic reactivity (Boyce & Chesterman, 1990; Jorgensen & Houston, 1989; Matthews, et al., 2001; Musante, et al., 2000; Phillips, et al., in submission). Whereas the exposures measured in the present study were all major stressful events, with a high average seriousness score, a negative association between life events and haemodynamic reactivity has been found in studies which have included more minor or even desirable events in their assessments (Boyce & Chesterman, 1990; Jorgensen & Houston, 1989; Matthews, et al., 2001; Musante, et al., 2000; Phillips, et al., in submission). This would suggest that although exposure to major negative events can induce blunting of acute stress reactivity, the phenomenon is not necessarily restricted to particularly stressful experiences. It has been long appreciated that desirable as well as undesirable experiences can perturb cardiovascular function (Light, 1981).

It is important to emphasize that it was the average self-reported impact of stressful events that proved predictive of blunting in this study, and not the frequency of events *per se*. As far as we are aware, this is the first demonstration that in the absence of an overall effect for frequency of events, the disruption caused by them is related to blunted haemodynamic reactivity. Our recent research on young adults suggested that it was the frequency of relatively minor events, some of a desirable nature, which was negatively associated with reactivity (Phillips, et al., in submission) and from other studies of adolescents or young

adults, it has been argued that blunting of reactivity will occur with exposure to events that have been resolved (Matthews, et al., 2001; Musante, et al., 2000) or have low subjective impact (Jorgensen & Houston, 1989). However, blunting of haemodynamic reactions to acute stress predicted by frequent but relatively innocuous events may be restricted to young adult or adolescent populations (Boyce & Chesterman, 1990; Musante, et al., 2000; Phillips, et al., in submission). More frequent but less severe life events are undoubtedly characteristic of younger individuals' experience, whereas older populations may be exposed to fewer but much more severe events. This may be particularly the case for the elderly. In the present study, the eldest cohort reported fewer events than the middle cohort, but rated them as being more serious. In addition, the negative association between average current disruptiveness of events and reactivity tended to be stronger in the eldest cohort. Thus, whereas it is the frequency of exposure to relatively minor events which is related to blunting of reactivity in younger populations, it may be the average impact of serious events that is associated with blunted reactivity in older adults. Hence, the precise effects of life events exposure on haemodynamic reactivity may depend on the complex interaction of the nature of the events and the age of the participants. However, such an interpretation should be qualified by the failure of cohort to emerge from regression analysis as a significant moderator of the relationship between life events impact and reactivity.

Although women did not report more events than men, they regarded them as more serious, more disruptive and more stressful on average. Further, the negative association between the average current disruptiveness of life events and haemodynamic reactivity tended to be stronger for women than for men. Very few studies have systematically examined sex differences in this context. In our previous study, the negative association between overall life events exposure and reactivity was stronger in women than in men and, indeed, men tended to show sensitisation of reactivity with exposure to undesirable events (Phillips, et al., in submission). In contrast, it has previously been reported that the negative relationship between chronic stress and cardiovascular reactivity was stronger for men than for women (Matthews, et al., 2001), although this appeared to be driven mainly by differences for work stress. However, the present assessment included life events domains such as health, marriage, relationships, and deaths that were likely to be as prominent for women as for men. Nevertheless, it should again be conceded that sex did not appear as a significant moderator of the association between life events impact and SBP reactivity in the present study, and thus caution is warranted.

The number of stressful life events was positively associated with SBP reactivity for participants from manual occupational households: that is, the more frequent the exposure to events, the greater the reactivity. Moderation analysis also indicated that whereas those from non-manual households tended to show blunted SBP reactivity in the face of frequent life events, those from manual occupational households showed sensitisation. In our previous study we also observed both blunting and sensitisation of haemodynamic reactivity within the same cohort (Phillips, et al., in submission); for young men, frequency of overall exposure to life events was negatively associated with reactivity whereas frequency of exposure to specifically undesirable events was positively associated reactivity. Further, frequent exposure to life events has been found to be associated with blunting of haemodynamic reactions to a car-driving simulation task, but enhanced reactivity to a social competence interview (Musante, et al., 2000). It would seem that whether blunting or sensitisation is observed may depend on the nature of the task, the sex of the participants, and now their socio-economic position.

A parsimonious explanation for the observed blunting of haemodynamic reactivity is that individuals exposed to high impact life events are simply less likely to engage with the less traumatic challenges that characterise most acute stress tasks. Such disengagement should be reflected in poorer stress task performance. Although there was a significant association between SBP reactivity and stress task performance, the negative relationship between life events impact and reactivity withstood adjustment for performance score. Another explanation for blunting involves physiological rather than psychological adaptation. The assumption here is that exposure to high impact life events desensitises the haemodynamic system, such that when confronted by a further challenge, an acute stress task, individuals experiencing such events will show diminished reactivity. This type of explanation has been proposed previously to account for blunting in this context (Boyce & Chesterman, 1990), and has been referred to as the 'inoculation effect' (Eysenck, 1983). In the present study, significant associations were restricted to SBP reactivity. However, other studies reporting blunting have also found the strongest effects for systolic blood pressure (Matthews, et al., 2001; Phillips, et al., in submission), and, in general, it would appear to be those indices of cardiovascular reactivity that are primarily driven by beta-adrenergic activation that are blunted by high life events exposure (Boyce & Chesterman, 1990).

The reactivity hypothesis, which postulates that large haemodynamic reactions to stress play a role in the development and expression of cardiovascular disease (Jennings, et al., 1981; Lovallo & Gerin, 2003; Manuck, 1994; Schwartz, et al., 2003; Treiber, et al., 2003), has been very influential, generating substantial numbers of studies. Large scale prospective studies of the reactivity hypothesis, particularly those using an active stress task, have observed consistent associations between reactivity and subsequent blood pressure status. However, the independent associations are small, usually accounting for only 1-3% of the variance in future blood pressure (Treiber et al., 2003). Data such as these suggest that reactivity may indeed be a contributing factor to the aetiology cardiovascular disease, although of insufficient magnitude to justify its adoption as a prognostic indicator in clinical practice (Carroll et al., 2003). Recently, it has been argued that, in addition to the magnitude of haemodynamic reactions to stress, the reactivity hypothesis must take account of individual differences in the frequency and/or potency of stress exposures (Carroll & Sheffield, 1998; Lynch, et al., 1998). The prevailing assumption, that it is the product of exposure and reactivity that confers cardiovascular disease risk, requires that reactivity levels are independent of individuals' histories of stressful life events. The present results, considered along with others which find a negative association between life events exposure and cardiovascular reactivity, question whether such a simple multiplicative hypothesis can be sustained. In addition, it would appear that factors such as the sex, age, and occupational status of participants also influence whether, or to what extent a negative association between life events experience and cardiovascular reactivity is observed. It is interesting to note that, in this sample, SBP reactivity provided the strongest prediction of five-year upward drift in blood pressure in the manual occupational group, accounting, in multivariate analysis, for 5% of the variance (Carroll et al., 2003). However, it is precisely this group which showed the strongest association between life events stress and blunting of SBP reactivity. These two findings neatly illustrate the questionable nature of the assumption that the product of life events exposure and reactivity would afford a better prognostic indicator of cardiovascular disease risk. Only large scale prospective reactivity studies in which life events are measured repeatedly would provide resolution. Future assessments of the present sample should also allow us some insight.

The present study suffers from a number of limitations. First of all, it was not designed specifically to explore the issue of whether and how life events are associated with the magnitude of cardiovascular reactions to acute mental stress. Thus, personality factors which could conceivably affect both the reporting of life events and reactivity were not measured. However, other studies have failed to demonstrate that such variables as neuroticism have any substantial impact in this context (Roy, et al., 1998). Nevertheless, it remains possible that some unmeasured dispositional factor is driving the association between life events and reactivity. This is particularly the case when it is the impact not the frequency of life events which are related to reactivity. It is also worth noting, that many of the previous studies of life events and reactivity, particularly the few large scale studies, were similarly opportunistic. Second, it is possible that the failure to find an overall association between reactivity and the frequency of events is attributable to the way in which life events were assessed; participants were permitted to select up to six life events only, rather than being free to nominate as many events as had occurred. In reality, participants on average selected only a small number of events and only eight (1%) reported having experienced six events, while 316 (52%) reported just one event, which suggests that the methodology was not unduly constraining.

Third, only SBP, DBP and pulse rate reactivity were measured, and only to one stress task. However, in a large cohort study, more comprehensive cardiovascular monitoring to a variety of stress tasks was not practicable. Further, it is worth noting that SBP reactivity to the task used in this study has been found to predict prospective changes in resting blood pressure status (Treiber, et al., 2003). It could be argued that the stress-task specificity reported in one study (Musante, et al., 2000) suggests that whether blunting, sensitization, or no association is observed might depend on the type of acute stress task employed. Of the studies which have used an obviously social stress task, public speaking or social competence interview, one reported that frequent life events blunted cardiovascular reactivity (Matthews, et al., 2001), two that life events aggravated cardiovascular reactivity (Matthews, et al., 1997; Musante, et al., 2000) and one reported no association (Benschop, et al., 1994; Cacioppo, Burleson, Poehlmann, Malarkey, Kiecolt-Glaser, et al., 2000). Of the studies which have employed a mental arithmetic stress task, on the other hand, three found blunting (Boyce & Chesterman, 1990; Jorgensen & Houston, 1989; Matthews, et al., 2001), whereas one observed enhanced cardiovascular reactivity (Lepore, et al., 1997). In sum, the pattern of effects would not appear to be wholly attributable to the nature of the stress task employed,

although it would also seem that blunting is more consistently observed with a mental arithmetic stress task than a wholly social stress task.

Fourth, although performance on the stress task could be considered a reasonable proxy for task engagement, it would have been better, in hindsight, to have included self-report measures of task impact. Fifth, it should be conceded that the associations that emerged from the present analyses are small in terms of the amount of variance explained. Nevertheless, the effect sizes that can be inferred from the other large scale studies of life events and reactivity are of the same order of magnitude (Matthews, et al., 2001; Musante, et al., 2000). In addition, studies examining the relationship between reactivity and follow-up blood pressure status find associations of a similar magnitude, (e.g.Treiber, et al., 2003), including a prospective analysis of this sample.(Carroll, et al., 2003). Further, the present study is the first to investigate the association between life events and stress reactivity in an older population. In addition, taken along with the results of our previous analyses of a young adult cohort, the present results suggest that there maybe genuine age variations in the nature of the association between life events exposure and stress reactivity, as well as possible variations contingent on sex and occupational status.

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Footnote 1

The full list of life events is available from the corresponding author on request.

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Table 1. Pearson Correlation Coefficients between the Disruptiveness and Stressfulness at the Time and Now and Seriousness of Life Events,

	Disruption then	Stressful then	Disruption now	Stressful now
Stressful then	.51*			
Disruption now	.47*	.22*		
Stressful now	.30*	.36*	.72*	
Seriousness	.48*	.63*	.25*	.30*

* p<.001

Table 2. Life Events Descriptive Statistics by Age Cohort, Sex and Occupational Status

	Middle	Eldest	Men	Women	Manual	Non-manual
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Number of events	1.98 (1.24)	1.68 (0.93)	1.89 (1.13)	1.83 (1.14)	1.77 (1.09)	1.93 (1.17)
Disruption then	3.35 (1.17)	3.34 (1.27)	3.22 (1.16)	3.45 (1.24)	3.27 (1.21)	3.40 (1.21)
Stressful then	3.82 (0.99)	3.85 (1.07)	3.62 (1.03)	4.01 (0.98)	3.79 (1.04)	3.86 (1.01)
Disruption now	2.17 (1.16)	2.34 (1.31)	2.14 (1.15)	2.32 (1.28)	2.26 (1.29)	2.22 (1.17)
Stressful now	2.24 (1.08)	2.33 (1.21)	2.10 (1.09)	2.41 (1.16)	2.26 (1.21)	2.28 (1.07)
Seriousness	6.31 (2.17)	6.85 (2.15)	6.22 (2.15)	6.78 (2.15)	6.56 (2.18)	6.49 (2.17)

Table 3. Mean (*SD*) Cardiovascular Activity at Baseline and during the Mental Stress Task and Cardiovascular Reactivity

	Baseline	Task	Reactivity
Whole sample			
SBP (mmHg)	133 (20.88)	146 (21.41)	12 (12.10)
DBP (mmHg)	82 (10.85)	89 (11.78)	7 (8.25)
Pulse rate (ppm)	66 (10.45)	73 (11.54)	7 (8.88)
Middle cohort			
SBP (mmHg)	127 (17.89)	140 (19.19)	13 (11.59)
DBP (mmHg)	81 (10.99)	88 (11.44)	8 (8.17)
Pulse rate (ppm)	66 (10.52)	74 (11.69)	8 (9.28)
Eldest cohort			
SBP (mmHg)	143 (21.45)	155 (21.33)	12 (12.87)
DBP (mmHg)	83 (10.48)	90 (12.26)	7 (8.34)
Pulse rate (ppm)	66 (10.35)	71 (11.14)	6 (8.09)

Table 4. Pearson Correlation Coefficients between the Occurrence and Average Impact of Life Events, at the Time and Now, and Cardiovascular Reactivity

	SBP reactivity	DBP reactivity	Pulse rate reactivity
Number of events	.01	–.01	.05
Disruption then	–.09*	–.01	–.03
Stressful then	–.02	–.02	–.05
Disruption now	–.14**	–.02	–.07
Stressful now	–.10*	–.04	–.06

*p< .05, ** p<.01

Table 5. Hierarchical Regression Models for Average Impact of Life Events: SBP Reactivity

a) Disruption then

	B	95%CI	ß	Δ R^2
Step 1				
Cohort	–0.10	–2.07 to 1.87	–.00	
Sex	–2.78	–4.68 to –0.88	–.12	
Body mass index	–0.41	–0.63 to –0.20	–.15	
Occupational status	0.12	–1.80 to 2.05	.01	
Performance score	0.14	0.04 to 0.25	.11	.06**
Step 2				
Cohort	–0.10	–2.06 to 1.87	–.00	
Sex	–2.59	–4.50 to –0.68	–.11	
Body mass index	–0.42	–0.63 to –0.20	–.15	
Occupational status	0.01	–1.91 to 1.93	.00	
Performance score	0.14	0.04 to 0.25	.11	
Disruption then	–0.84	–1.62 to –0.06	–.08*	.01*

b) Disruption now

Step 2				
Cohort	0.04	–1.92 to 2.00	.00	
Sex	–2.60	–4.49 to –0.70	–.11	
Body mass index	–0.42	–0.63 to –0.21	–.16	
Occupational status	0.11	–1.80 to 2.02	.01	
Performance score	0.13	0.02 to 0.23	.10	
Disruption now	–1.18	–1.95 to –0.41	–.12*	.01*

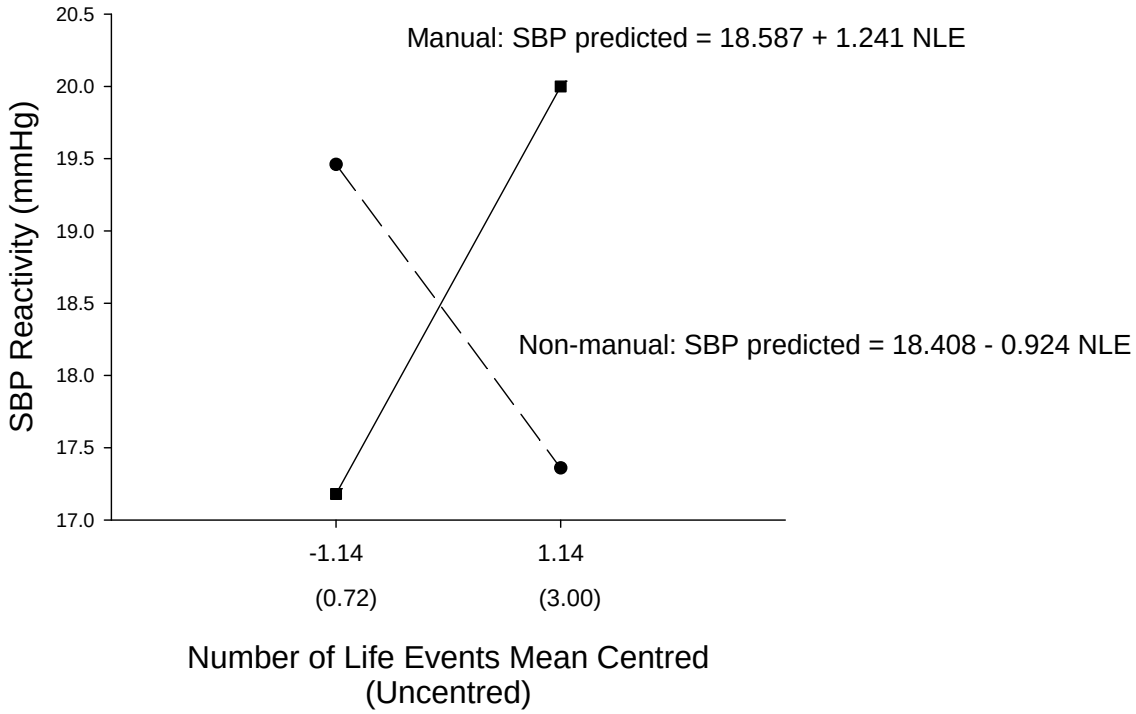
* $p < .05$, ** $p < .01$

Table 6. Pearson Correlation Coefficients Between the Occurrence and the Average Impact of Life Events and SBP Reactivity for the Two Age Cohorts, Men and Women, and Manual and Non-manual Occupational Groups.

	Number of events	Disruption then	Stressful then	Disruption now	Stressful now
Middle Cohort	.04	–.04	.00	–.10	–.07
Eldest Cohort	–.03	–.14*	–.04	–.18**	–.14*
Men	–.08	–.10	–.03	–.10	–.06
Women	.09	–.05	.05	–.15**	–.11*
Manual	.13*	–.10	–.02	–.14*	–.08
Non-manual	–.08	–.08	–.02	–.13*	–.13*

*p< .05, ** p<.01

Figure 1. Interaction between Number of Life Events and Occupational Status for SBP Reactivity. Separate regression lines are plotted for Manual and Non-manual Occupational Groups. $\hat{Y}$ = predicted reactivity. On the X axis the mean-centred values are presented with the uncentred values in parentheses.


Manual: SBP predicted = 18.587 + 1.241 NLE
Non-manual: SBP predicted = 18.408 - 0.924 NLE
SBP Reactivity (mmHg)
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
-1.14
(0.72)
1.14
(3.00)
Number of Life Events Mean Centred
(Uncentred)